Program Commitment Agreement

HIGH PERFORMANCE COMPUTING & COMMUNICATIONS (HPCC) PROGRAM

It is the responsibility of each of the signing parties to notify the other in the event that a commitment cannot be met, and to initiate the timely renegotiations of the terms of this agreement.

Agreements:

Enterprise Associate Administrator	Date
Administrator	Date

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Baseline	Version 1.0	5/15/00	

PROGRAM COMMITMENT AGREEMENT

High Performance Computing and Communications (HPCC) Program

PROGRAM OBJECTIVES

The main objective of the Federal HPCC R&D programs is to extend U.S. technological leadership in high performance computing and computer communications. As this is accomplished, these technologies will be widely disseminated to accelerate the pace of innovation and improve national economic competitiveness, national security, education, health care, and the global environment. The NASA HPCC program is a critical element of this national objective, as well as a central element of NASA's effort to engage high performance computing and communications technologies to achieve NASA's aggressive mission goals.

The specific goals of NASA's HPCC program are to (1) accelerate the development, application and transfer of high performance computing capabilities and computer communications technologies to meet the engineering and science needs of the U.S. aerospace, Earth and space sciences, spaceborne research, and education communities and (2) accelerate the distribution of technologies to the American public.

NASA's primary contribution to the Federal program is its leadership in the development of software and algorithms for high-end computing and communication systems which will increase system effectiveness and support the development of high-performance, interoperable, and portable computational tools. As HPCC technologies are developed, NASA will use them to address its computational aerospace transportation systems, Earth science, and space science research challenges. These challenges require significant increases in computational power, network speed, and the system software required to make these resources effective in real-world science and engineering environments. NASA's research problems include improving the design and operation of advanced aerospace transportation systems, enabling people at remote locations to communicate more effectively and share information, increasing scientists' abilities to model the Earth's climate and predict global environmental trends, further our understanding of our cosmic origins and destiny, and improving the capabilities of advanced spacecraft to explore the Earth and solar system. Furthermore, the NASA HPCC program supports research, development, and prototyping of technology and tools for education, with a focus on making NASA's data and knowledge accessible to America's students.

In support of these objectives, the NASA HPCC program develops, demonstrates, and prototypes advanced technology concepts and methodologies, provides validated tools and techniques, responds quickly to critical national issues, facilitates the infusion of key technologies into NASA missions activities and the national engineering, science and education communities, and makes these technologies available to the American public. The program is conducted in cooperation with other U.S. Government programs, the U.S. industry, and the academic community.

PROGRAM OVERVIEW

HPCC is a computing and communications research program that pursues technologies at various levels of maturity. Applications in the areas of aerospace technology, Earth science, space science, and education are used as drivers of HPCC's computational and communication technology research, providing the requirements context for the work that is done.

The program has been organized into five customer-focused projects which strive to develop, demonstrate, and infuse into customer processes integrated systems of application, system software, and testbeds which, in total, meet the overall HPCC program goal and each of the customer impact and technical objectives:

- Computational Aerospace Sciences (CAS)
- Earth and Space Sciences (ESS)
- Remote Exploration and Experimentation (REE)
- Learning Technologies (LT)
- NASA Research and Education Network (NREN)

with three cross-cutting technology areas:

- Applications
- System Software
- Testbeds

The 1999 Program Commitment Agreement (PCA) called for an evaluation of the program in light of refocusing efforts within the federal information technologies activities and recent technical trends. The intent of this evaluation activity was to establish that the NASA HPCC program continue to meet:

- NASA commitments to Federal information technologies activities.
- Requirements of NASA's stakeholder Enterprises and Headquarters Office.

During Phase I the HPCC program (FY92-FY99) successfully prototyped high-performance computing and communication technologies to enable pioneering advances in:

- High-fidelity, multi-disciplinary simulations in Earth and space sciences, and aerospace transportation engineering.
- Commodity-based space-borne supercomputing.
- Networking technologies to support NASA missions, with particular focus on the NASA education goals.

Beginning in Phase II (FY00-FY06), the HPCC program enters the next natural phase in any technology development program; the generalization, refinement, and insertion of technologies into the processes of most relevance to HPCC's stakeholders. Implicit is a shift in focus from proof-of-concept studies to development of an effective technology legacy. In addition to the natural maturation of the technology, there is always the need to adapt to relevant technical trends. In Phase II, the HPCC program is explicitly addressing the pervasive technical trends:

- Distributed, multi-disciplinary teams.
- Distributed computing, storage, and communication resources.
- Increasing importance of software bottlenecks.

<u>Computational Aerospace Sciences (CAS) Project</u>: CAS addresses the high end computing needs of the NASA Aero-Space Technology Enterprise and the extended aerospace community, including other government agencies, industry, and academia. The CAS goal is to enable improvements to NASA technologies and capabilities in aerospace transportation through the development and application of high performance computing technologies, transferring these technologies to NASA and the broader aerospace community. This will provide the aerospace community with key tools necessary to reduce design cycle times and increase fidelity in order to improve the safety, efficiency, and capability of future aerospace vehicles and systems. The CAS project works with other Aero-Space Technology Enterprise programs and the extended aerospace community to select high priority areas that have bottlenecks or limits that could be addressed through the application of high end computing. These challenging, customer-focused applications guide efforts on advancing aerospace algorithms and applications, system software, and computing machinery. These advances are then combined to demonstrate significant improvements in overall system performance and capability. In Phase II (FY00-FY06), the CAS project has strengthened its focus on supporting distributed multi-disciplinary teams utilizing distributed resources and insuring the most effective use of these HPCC technologies by NASA aerospace technology activities.

<u>Earth and Space Science (ESS) Project</u>: ESS develops generic tools to demonstrate high end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical, and biological processes affecting the Earth, the solar-terrestrial environment, and the universe. This means new understanding of the formations, distances and revolutions of the celestial bodies, heliospheric dynamics, protecting satellites from solar activity and predicting climate change. The computing techniques developed as a part of the ESS project will further the development of an integrated suite of multidisciplinary models and computational tools leading ultimately to scalable global climate simulations and to the solution of highly energetic multiple-scale problems associated with space and astrophysics. From these mathematical coding techniques both modeling applications and software interoperability across the research communities (Earth Science) become possible. These modeling tools provide computing capacity and enhanced software coding through the use of software engineering techniques. They increase computational performance affected by areas such as memory latency and cache coherence. The HPCC ESS project will ensure the migration of numerical models to lower cost commodity based platforms and address technology infusion into scientific needs. The ESS project will provide R&D technology and research tools for applications needs that may be extended through other enterprises activities to the public, state and local governments. In Phase II (FY00-FY06), the ESS project has strengthened its focus on supporting the broad use of HPCC technologies to support multi-disciplinary Earth and space science modeling and data assimilation.

Remote Exploration and Experimentation (REE) Project: NASA and DOD requirements for space-capable computing technology are becoming more demanding, especially with regard to available power and cooling, performance, reliability, and cost. The REE project seeks to leverage the considerable investment by the ground based computing industry to bring supercomputing technologies into space within the constraints imposed by that environment. The availability of onboard computing capability will enable a new way of doing science in space at significantly reduced overall cost. This technology will embrace architectures scalable from sub-watt systems to hundred-watt systems that support a wide range of missions, from Earth observing missions to deep space missions lasting ten years or more. Earth observing missions are typically conducted in a data-rich/power-rich environment with sensors capable of producing gigabits of data per second. Deep space missions require ultra-low-power and low-mass systems capable of autonomous control of complex robotic functions. These space-based systems must be highly reliable and fault tolerant under space radiation conditions. The goals of the REE are to (1) demonstrate a process for rapidly transferring commercial high-performance computing technology into low power, fault tolerant architectures for space; and (2) demonstrate that high-performance onboard processing capability enables a new class of science investigation and highly autonomous remote operation.

Learning Technology (LT) Project: LT uses NASA's inspiring mission, unique facilities, and specialized workforce in conjunction with the best emerging technologies to promote excellence in America's educational system. LT directly supports the NASA Office of Human Resources and Education goals and objectives, including those of the Educational Technology program. LT continues to promote computer and network literacy. LT enhances the public's scientific and technical familiarity, competence, and literacy through internet based NASA projects in an interactive network environment. LT has contributed dozens of legacy projects to the schools of our nation. In the next few years LT will expand its suite of technology applications to show case multisensory and multimedia educational products. In Phase II (FY00-FY06), the LT project has strengthened its focus on developing, distributing, and disseminating advanced learning technologies, including multisensory and multimedia products, to both formal and informal educational institutions.

NASA Research and Education Network (NREN) Project: NREN is extending U.S. technological leadership in computer communications through research and development that advances leading-edge networking technology and services. This leadership is made possible by utilizing a next generation network testbed that fuses new technologies into NASA mission applications, enabling new methodologies for achieving NASA science goals. Moreover, these networking technologies will provide NASA missions with the advantages of enhanced data sharing, interactive collaboration, visualization and remote instrumentation. NREN will meet these goals through technology integration and collaborations within the multi-agency Next Generation Internet program, academia and industry. In Phase II (FY00-FY06), the NREN project has strengthened its focus on the development of advanced networking strategies such multicasting, quality-of-service, and network tailoring and the tailoring of these technologies to support NASA goals.

Three cross-cut technology areas have been identified. In each area there is an opportunity for significant synergy across the HPCC projects and with other activities. In the application area, algorithms, tools, and framework technologies can be shared. In the system software area, many of the issues of interoperability, portability, reliability, and resource management are common. Testbed technologies and systems are synergistic for ground-based systems, with spin-offs to space-borne systems sought. To enable these synergies, integration management teams for each cross-cut technology area provide awareness of evolving technical trends and ensure inter- and intra-program collaboration. These teams provide the knowledge base of emerging technical trends, identify promising collaborations and identify issues requiring attention.

Specific HPCC customers are other NASA programs and organizations, selected segments of the U.S. aerospace manufacturing industry, academic research labs, other U.S. Government Agencies, the U.S. education community, and the information technology industry. A listing of customers by project is shown in the following table:

PROJECT	PRINCIPAL GOVERNMENT CUSTOMERS	PRINCIPAL INDUSTRY AND ACADEMIC CUSTOMERS
Computational Aerospace Sciences (CAS)	NASA Aero-Space Technology Enterprise, researchers in applied computational aerospace sciences and computer science, engineers developing aeronautical and space transportation systems	Aerospace vehicle and engine manufacturers; Information Technology industry supplying commercial technology to aerospace community
Earth and Space Sciences (ESS)	NASA's Earth Science Enterprise, Space Science Enterprise, Government research labs performing scientific research in Earth and space sciences	University labs performing scientific research in Earth and space sciences
Remote Exploration and Experimentation (REE)	NASA's Earth Science Enterprise, Space Science Enterprise, NASA and DoD missions requiring spaceborne embedded high-end computing	Commercial satellite industry
Learning Technologies (LT)	NASA's Office of Human Resources and Education, Federal, State and Local Government Agencies and Departments involved in K-12 education	Information Technology industry supplying commercial technology for K-12 education
NASA Research and Education Network (NREN)	NASA's Aero-Space Technology Enterprise, Earth Science Enterprise, Space Science Enterprise, and Office of Human Resources and Education, as well as other federal organizations requiring state-of-the-art networking	Information Technology industry supplying commercial technology to aerospace, Earth and space sciences and education communities

PROGRAM AUTHORITY

The Ames Research Center is the NASA lead center for the management and implementation of the HPCC program. Designated supporting centers include Dryden Flight Research Center, Glenn Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory, Johnson Space Center, Kennedy Space Center, Langley Research Center, Marshall Space Flight Center and Stennis Space Center. The governing program management council is the NASA Headquarters Program Management Council (PMC). The Associate Administrators for the Offices of Aero-Space Technology, Earth

Science, Space Science and Human Resources and Education are all members of the HPCC Executive Committee of which the Associate Administrator, Office of Aero-Space Technology, is the chair. The HPCC Executive Committee establishes and meets regularly to validate strategic program direction and policy guidelines as described in the Memorandum of Agreement (see Internal NASA Agreements section). Each Associate Administrator is the approving official for additions or deletions of projects for those areas in which they provide funding.

The program and/or its projects will be subject to a termination review based on the following thresholds:

- Technical performance: Projections that the program will be unable to meet its overall minimum success criteria defined in the table in the Technical Performance section.
- Cost commitment: Projected cost to complete the program exceeds the targeted development cost of $835.9 million.
- Schedule commitment: Projected schedule to complete the HPCC program extends beyond the target completion date of September 2006.

TECHNICAL PERFORMANCE

The NASA HPCC program is designed to support the overall Federal high performance computing and communications goals while addressing agency-specific computational challenges beyond the projected capabilities of commercially-available computing and communications systems. These computational challenges have been chosen for their impact on NASA's missions, their national importance, and the technical challenge they provide to the NASA HPCC program.

The science and engineering requirements inherent in the selected NASA applications require at least three orders of magnitude improvement in high-performance computing and networking capabilities over the capabilities that existed at the beginning of the program in FY1992. Elements of the program have achieved a two orders of magnitude improvement in high-performance computing performance by the end of 1999 (Phase I). In Phase II, the balance of the performance requirements will be achieved. Of equal importance, significant advances in interoperability, portability, reliability, usability, and resource management are essential to the pervasive and effective application of increased computational and communication performance to NASA's goals. NASA's requirements in these areas are beyond the planning horizons of the commercial sector. NASA must develop new approaches and technologies in these areas and demonstrate their feasibility before the commercial sector can move aggressively into these areas and eventually meet NASA's requirements.

Each of the five HPCC projects will be assessed based on target performance, as well as minimum technical success requirements as follows:

Performance Goals	*Projects*	*Performance Targets*	*Exit Criteria (Minimum Success)*

Customer Impact: Infuse HPCC technologies in to mission critical Aero-Space Technology Enterprise processes, and document discernable improvements in the stakeholders' processes and, if possible, final products as a result of the use of HPCC technologies.	CAS NREN	Use of HPCC technologies to reduce the design time of at least 10 designs, from 5 Aero-Space Technology programs.	Use of HPCC technologies to reduce the design time of at least 8 designs, from 4 Aero-Space Technology programs.
	CAS NREN	Use of HPCC technologies to enable the analysis or simulation of 3 elements of the National Air Space.	Use of HPCC technologies to enable the analysis or simulation of 2 elements of the National Air Space.
Customer Impact: Infuse HPCC technologies in to mission critical Earth Science and Space Science Enterprises processes, and document discernable improvements in the stakeholders' processes and, if possible, final products as a result of the use of HPCC technologies.	ESS	25 research groups operating at 10X improvement and 40% interoperating with Earth and space science frameworks impacting at least 5 scientific communities.	20 research groups operating at 8X improvement and 40% interoperating with Earth and space science frameworks impacting at least 4 scientific communities.
	REE	Spaceflight-ready system delivering 300 MOPS/watt with a reliability of 0.99 over 5 years on 3 applications.	Spaceflight-ready system delivering 250 MOPS/watt with a reliability of 0.98 over 5 years on 2 applications.
	NREN	Use of HPCC networking technologies to enable 4 projects.	Use of HPCC networking technologies to enable 3 projects.
Customer Impact: Infuse HPCC technologies in to mission critical Office of Human Resources and Education processes, and document discernable improvements in the stakeholders' processes and, if possible, final products as a result of the use of HPCC technologies.	LT	Distribute LT technologies to at least 10,000 American educational points of contact.	Distribute LT technologies to at least 8,000 American educational points of contact.
	LT	Routine and persistent use of LT technologies at 1000 American formal and informal educational institutions.	Routine and persistent use of LT technologies at 800 American formal and informal educational institutions.
Dramatically increase the computer and communications performance available for use in meeting NASA mission requirements.	CAS ESS	250 Gigaflops sustained on applications, ground based NASA testbed.	200 Gigaflops sustained on applications, ground based NASA testbed.
	REE	300 MOPS/watt, space ready.	250 MOPS/watt, space ready.
	NREN	1 Gigabits/second end-to-end sustained, ground based.	0.8 Gigabits/second end-to-end sustained, ground based.
Demonstrate the effective use of applications on NASA aerospace systems, Earth and space sciences, or education challenges.	CAS	Complete each a vehicle and a propulsion system analysis in one day.	Complete each a vehicle and a propulsion system analysis in two days.
	ESS	On a weekly basis, ensembles of one-year forecasts of climate event using a 1 degree atmosphere and a 1/3 degree ocean resolution. Assimiliation of atmospheric data at 1/2 degree resolution at a rate of 30 days per day.	On a 10-day basis, ensembles of one-year forecasts of climate event using a 1 degree atmosphere and a 1/3 degree ocean resolution. Assimiliation of atmospheric data at 1/2 degree resolution at a rate of 20 days per day.

Performance Goals	*Projects*	*Performance Targets*	*Exit Criteria (Minimum Success)*
Dramatically increase the interoperability of application and	CAS	Interoperation among ten tools spanning at least three disciplines.	Interoperation among eight tools spanning at least three disciplines.

system software operating on high-performance computing and communications systems available for use in meeting NASA mission requirements.	ESS	Interoperation among 3 applications in Earth System Modeling Framework, and 2 applications in 4 other frameworks.	Interoperation among 2 applications in Earth System Modeling framework, and 2 applications in 3 other frameworks.
	NREN	Multicast among 5 networks, and quality of service (QoS) and traffic engineering capabilities among 3 networks.	Multicast among 4 networks, and QoS and traffic engineering capabilities among 2 networks.
	CAS ESS	Integration of a new tool into a framework in 1 day.	Integration of a new tool into a framework in 2 days.
	CAS NREN	Integration of new system into a grid and a new networking into a testbed in 1 day for each.	Integration of new system into a grid and a new networking into a testbed in 2 days for each.
Dramatically improve the portability of application software and data to new or reconfigured high-performance computing and communications systems available for use in meeting NASA mission requirements.	CAS ESS NREN	Port an application on a new system within 1 week and a modified system within 1 day.	Port an application on a new system within 2 weeks and a modified system within 2 days.
Dramatically improve the reliability of user-requested events executing on high performance computing and communications systems available for use in meeting NASA mission requirements.	REE	Completion of 99% of computations over a 5-year time period.	Completion of 98% of computations over a 5-year time period.
	CAS NREN	Successful execution of 99% of user events over 24 hour period on system including 10 resources, including 1 computer, 1 storage system, and at least 1 wide-area-network.	Successful execution of 98% of user events over 24 hour period on system including 8 resources, including 1 computer, 1 storage system, and at least 1 wide-area-network.
Dramatically improve the ability to manage heterogeneous and distributed high-performance computing, storage, and networking resources available for use in meeting NASA mission requirements.	CAS NREN	Allocate resources to a user event, including 10 resources, including 1 computer, 1 storage system, and at 1 wide-area-network.	Allocate resources to a user event, including 8 resources, including 1 computer, 1 storage system, and at 1 wide-area-network.
Dramatically improve the usability of high-performance computing and communications tools and techniques available for use in meeting NASA mission requirements.	CAS	"Visually-based" (e.g., graphical, virtual reality) assembly and execution of applications.	"Visually-based" (e.g., graphical, virtual reality) assembly and execution of applications.
	REE	Spaceborne computing has the same usability as commercial equivalent.	Spaceborne computing has the same usability as commercial equivalent.
	NREN	Integration of networking enhancements into applications codes that allow improvement perceived performance.	Integration of networking enhancements into applications codes that allow improvement in perceived performance.
	LT	Ability to receive kinetic, auditory, and visual input and present multimedia information through full motion 3D imaging and haptic feedback.	Ability to receive kinetic, auditory, and visual input and present multimedia information through full motion 3D imaging and haptic feedback.

SCHEDULE COMMITMENTS

The major deliverables for the NASA HPCC program, shown below, are the development of key technologies, the demonstration of the impact of these technologies on NASA missions, and establishing the sustainable and wide-spread use of these HPCC program technologies. The program milestones contributing to these deliverables are presented in Appendix B and will result in the exit criteria described in the prior section. The program is targeted to be completed by September 2006. Minimum success criteria is to complete the program exit criteria no later than the target completion date.

PCA Milestones	**Mo/Yr**
Develop component technologies for performance	9/01
Demonstrate integrated HPCC technologies	9/02
Develop component technologies for reliability and resources management	6/03
Develop component technologies for interoperability and portability	9/03
Develop component technologies for usability	9/04
Demonstrate significant engineering, scientific, and educational impacts from integrated HPCC technologies	9/05
Establish sustainable and wide-spread customer use of HPCC technologies	9/06

COST COMMITMENTS

As a technology development program, HPCC will provide capabilities and reduce the risk of technology application by industry and other government agencies. This program will be accomplished within the resource allocation shown in the Program Cost Commitment table shown on the next page. All resources are for research and technology.

ACQUISITION STRATEGY

Free and open competitive procurements will be used to the maximum extent possible. Among the procurement vehicles to be used in the NASA HPCC program are NASA Research Announcements (NRA), NASA Cooperative Agreement Notices (CAN), and Request for Proposals (RFP). These vehicles will result in grants, cooperative agreements and contracts. Cooperative Agreement Notices (CAN) will be used to the maximum extent possible for the incorporation of technology and applications into the program. The Scientific and Engineering Workstation Procurement (SEWP) contract will be used for major equipment purchases in instances where cooperative agreements are not appropriate. Interagency agreements for joint R&D endeavors and the utilization of early prototype systems will also be used.

PROGRAM COST COMMITMENTS (PCC), $M FOR HPCC PROGRAM											
COST COMMITMENT CATEGORIES		Prior	FY00	FY01	FY02	FY03	FY04	FY05	BTC	TOTALS	RESPONSIBLE AA SIGNATURE
DEVELOPMENT (DCC)	Formulation (Preapproval/Definition										
	Implementation (Development)	447.9	69.4	74.9	76.2	67.0	56.5	29.4	14.6	835.9	
	Aero-Space Technology	*262.2*	*24.2*	*24.2*	*25.5*	*27.3*	*27.4*	*25.4*	*14.6*	*430.8*	EAA, Code R
	Earth Science	*145.9*	*21.9*	*21.8*	*21.8*	*21.8*	*11.2*	*0.0*	*0.0*	*244.4*	EAA, Code Y
	Space Science	*18.8*	*19.5*	*24.9*	*24.9*	*13.9*	*13.9*	*0.0*	*0.0*	*115.9*	EAA, Code S
	Human Resources & Education	*21.0*	*3.8*	*4.0*	*4.0*	*4.0*	*4.0*	*4.0*	*0.0*	*44.8*	EAA, Code F
	Totals	**447.9**	**69.4**	**74.9**	**76.2**	**67.0**	**56.5**	**29.4**	**14.6**	**835.9**	
OPERATIONS (OCC)	Implementation (Operations/MO&DA)										
	Totals										
OTHER	CoF										
	Launch Vehicle										
	Tracking and Data										
	Other										
	Totals										CFO/Comptroller*
	Totals (PCC)	**447.9**	**69.4**	**74.9**	**76.2**	**67.0**	**56.5**	**29.4**	**14.6**	**835.9**	

* Budget Profile consistent with FY 01 President's Budget

HIGH RISK AREAS

Risks exist within each project and task of the HPCC program—whether the risk is technical, in terms of achieving a certain performance level, or programmatic, in the form of potential time or financial deficits. Most of these risks will be managed within the particular elements by reallocation of funds or work force, redirection of research activities, or descoping. Decisions to reallocate funding among the projects or descope projects will be based technology elements most critical to achieving HPCC goals. Input for these decisions will result from project status reviews, ongoing systems studies and interaction with customers, stakeholders and partners. A prioritized descope plan will be maintained by the HPCC Program Manager. The technology integration efforts provided by the cross-cutting technology teams will provide additional data for programmatic decisions. The overall areas of risks and approaches to minimize the risks for the HPCC program are described as follows.

<u>Relevance:</u> NASA's HPCC mission requires currency with the leading edge of technology and a technical vision that remains consistent with rapidly emerging and evolving technology trends. To minimize the potential risk of investing resources in ineffective technology, NASA frequently meets with industry, academia, and other Federal agencies to help plan the future of the technology. NASA HPCC also needs to ensure that the program's activities remain relevant to evolving customer and stakeholder

requirements. To maintain customer relevance, the HPCC program validates customer priorities and technology requirements through regular meetings and interactions with customer representatives.

Resources: Successful execution of the HPCC program is dependent on access to adequate funds, world-class expertise, appropriate and effective technologies, and high-performance computing and communication testbeds. For example, to ensure access to high-performance computing and communications testbeds it is critical that NASA continues to pursue a quick and responsive procurement mechanism for acquiring experimental supercomputers that is compatible with the pace of innovation. To minimize the potential risks, NASA has developed in-house procurement vehicles that permit rapid vendor responses. NASA also partners with other Federal agencies to leverage off other procurement vehicles. To ensure the testbeds are functional for their intended purposes, NASA has invested in a diversity of technologies in multiple geographic locations that minimize natural and technical disasters. NASA HPCC also partners with other NASA programs, Federal agencies, industry, and academia to use their facilities when necessary. NASA has established an allocation and scheduling system for its testbeds that ensures best possible use of the facilities. Additionally, NASA is pursuing more cost-effective means of providing versatile testbeds for the future.

Leveraging: Coordination of NASA HPCC research both internally and externally to the program is critical to meeting the NASA and Federal high-performance computing and communication goals. Externally, formal and informal agreements are used to strengthen collaborative efforts with other government agencies, industry and academia. These agreements are often the product of cooperative planning to ensure a cohesive plan with no unforeseen consequences. Within the HPCC program, formal cross-project technology teams assist the program and projects in identifying technology gaps, potential duplication, and opportunities for enhanced coordination and integration.

In summary, an ongoing risk management approach will be employed in the HPCC program. Risk management plans will be developed and maintained for both the overall program as well as each individual project. The approach to be followed will be consistent with NASA NPG 7120.5A. All NASA management personnel in the HPCC program will receive periodic risk management training updates from a risk management instructor, certified by the NASA Office of Safety and Mission Assurance.

INTERNAL NASA AGREEMENTS

1. NREN and NASA Integrated Services Network (NISN): Memorandum of Understanding on internal technology collaboration and transfer to NASA operational networks, May 1997.
2. Memorandum of Understanding for the HPCC Executive Committee among the Offices of Aero-Space Technology, Earth Science, Space Science and Human Resources & Education, date TBD.

EXTERNAL AGREEMENTS

1. National HPCC Software Exchange. NASA and other Federal HPCC agencies, working in concert with academia and DoE laboratories, have developed a National HPCC Software

Exchange to provide an infrastructure that encourages software reuse and the sharing of software modules across organizations through an interconnected set of software repositories. This multi-agency effort was initiated in FY1992 and continues through FY2002.
2. Office of Management and Budget "Budget of the United States Government, Fiscal Year 2000" The Budget includes a descriptive discussion of Federal programs organized by function. Section 7, "Promoting Research," specifically describes the HPCC program as well as the President's overall information technology objectives.
3. NREN and Computing and Interdisciplinary System Office (CISO)/GRC: Memorandum of Understanding on hybrid technology collaboration and advanced application demonstrations, November1997.
4. Next Generation Internet: NGI Implementation Plan (available at http://www.ngi.gov), Feb. 1998.
5. MOU between NASA and Silicon Graphics Inc. for collaborations in high-end computing, May 1999.

INDEPENDENT EVALUATION

Yearly assessment of progress and continued ability to execute the commitment defined herein will be performed through Independent Annual Reviews (IAR), continuing over the life of the program.

TAILORING

The HPCC program is in accordance with the Program and Project Management Processes and Requirements presented in NASA's Procedures and Guidelines Document (NPG 7120.5A) that became effective April 3, 1998.

PCA ACTIVITIES LOG

Date	Event	Change	Addendum	Cancellation Review Required	EAA Signature	Administrator Signature
12/93	PCA Submitted	N/A	N/A	No		
1/94	FY95 Congressional Budget Modifications	Appendix A Ref #1	Ref. #1	No		
6/94	FY95 Post Congressional Budget Modifications	Elimination of 3rd IITA CAN	N/A	No		
9/94	FY96 OMB Request	Elimination of 2nd IITA CAN	N/A	No		
3/95	FY96 HPCC Plan Update	Administrative changes	Eliminated milestones tracked at lower levels	No		
3/96	FY97 Congressional Budget	Milestone reorganization and IITA funding cut	Ref. #2	No		
2/97	FY98 Congressional Budget, update to revised program plan	Incorporation of NGI	Ref. #3	No		
4/99	FY99 PCA revisions approved	New PCA milestones added Reformatted in conformance with NPG 7120.5A	Ref. #4	No		
11/99	FY00 Update	Phase II	Ref. #5	No		

PROGRAM COMMITMENT AGREEMENT

High Performance Computing and Communications (HPCC) Program

Appendix A — Changes to Program Commitment Agreement

Reference
Number

1. January 1994. Additional CAS work content was added in response to expressed need from aeronautics airframe and propulsion industry. IITA milestones were realigned to reflect budget stretch and IRM reductions.
2. March 1996. For program management efficiencies and to leverage the technological developments of each project, similar CAS and ESS milestones were combined. Updated out-year milestones. Eliminated IITA milestones due to funding cuts.
3. February 1997. Responded to Presidential initiative to develop NGI. Developed new NGI milestones and replanned $25M in FY98-00 to meet the milestones.
4. April 1999. New PCA milestone added calling for refresh of program relationship to customer base, as well as alignment with emerging Federal information technology trends. PCA reformatted in conformance with NPG 7120.5A.
5. March 2000. New PCA reflecting refresh of customer base relationships, as well as alignment with emerging Federal information technology trends completed.

PROGRAM COMMITMENT AGREEMENT

High Performance Computing & Communications (HPCC) Program

Appendix B — Schedule and Budget Baseline

SCHEDULE BASELINE

Milestones	Previous Baseline	Current Baseline	Actual
FY 93			
Interconnects to NSFnet at 45 Mbps		6/93	Complete
Initial development testbeds installed using available high-performance hardware (1-10 Giga-FLOPS sustained)		9/93	Complete
FY 94			
Install 10-50 GigaFLOPS sustained testbed (scalable to 100 GigaFLOPS) for Grand Challenge teams		6/94	Complete
Demonstrate T-3 (45 Mbps) Level 3 HPCC interconnects		9/94	Complete
FY 95			
Demonstrate satellite-based gigabit applications using the Advanced Communications Technology Satellite (ACTS) and associated ground terminals		6/95	Complete
Evaluate initial K-12 digital educational material		9/95	Complete
Demonstrate initial remote sensing database (RSD) applications over the National Information Infrastructure		9/95	Complete
FY 96			
Install 50-100 GigaFLOPS sustained scalable testbed		9/96	Complete
Demonstrate portability and scalability of software components and tools to TeraFLOPS systems		9/96	Complete
FY 97			
Demonstrate integrated, multidisciplinary applications on TeraFLOPS scalable testbeds		9/97	Complete
FY 98			
Install 100-250 GigaFLOPS sustained scalable TeraFLOPS testbed		6/98	Complete
Provide mature remote sensing data applications over the National Research and Education Network		9/98	Complete
Distribute mature K-12 curriculum products over the National Information Infrastructure		9/98	Complete
Demonstrate results of mature DLT projects		9/98	Complete
FY 99			
Establish next generation internetwork exchange for NASA to connect Grand Challenge universities' principal investigators to NASA high performance resources		10/98	Complete
Demonstrate 200-fold improvements over FY1992 baseline in time to solution for Grand Challenge applications on TeraFLOPS testbeds		6/99	Complete
Evaluate HPCC program and project plans towards meeting objectives and goals of the Information Technology Initiative		8/99	Complete

Demonstrate portable scalable distributed visualization of multi-terabyte 4D datasets on TeraFLOPS scalable systems	9/99	Complete
Complete the initial efforts of HPCC by demonstrating improvements for aerosciences, Earth science, and space science applications	9/99	Complete

Milestones		Previous Baseline	Current Baseline	Actual
FY 00				
1.1	Establish high-performance testbed for application performance		9/00	
4.1	Prototype/establish advanced technologies that serve as a catalyst for learning environment use of engineering and scientific data		9/00	
5.1	Demonstrate embedded applications on 1st generation spaceborne computing testbed		9/00	
FY 01				
1.2	Establish 1st generation scalable embedded computing testbed		6/01	
1.3	Develop and apply technologies to measure and enhance performance on high-performance testbeds		9/01	
5.2	Demonstrate integrated learning technology products in relevant educational environments		9/01	
FY 02				
5.3	Demonstrate improvement in time-to-solution for aerospace applications		12/01	
2.1	Develop real-time reliability for spaceborne computing		3/02	
3.1	Tools and techniques for interoperable and portable applications in aerospace, Earth science and space science communities		3/02	
5.4	Demonstrate embedded applications using fault-tolerant techniques		6/02	
3.2	Interoperable and portable networking technologies		9/02	
4.2	Production-ready breakthrough technologies that serve as a catalyst for learning environment use of engineering and scientific data		9/02	
5.5	Demonstrate significant improvements in Earth and space science application codes		9/02	
5.6	Demonstrate end-to-end networking capabilities on NASA mission-oriented applications		9/02	
FY 03				
2.2	Develop embedded tools and services for autonomous resource estimation/request of local and distributed ground-based systems		12/02	
2.3	Develop tools for reliability of ground-based computing systems		6/03	
3.3	Interoperable and portable systems, services and environments		9/03	
6.1	Establish impact on Earth and space sciences through the demonstration of a production-ready high-performance Earth and space science computational simulations validated by NASA Enterprise observational mission data		9/03	
FY 04				
4.3	Develop tools to improve usability of aerospace simulation capabilities		3/04	
6.2	Establish impact on space mission through the demonstration of a flight-ready integrated system software, testbed, and application system		6/04	
4.4	Develop prototype of revolutionary multisensory multimedia technology for education		9/04	
7.1	Establish sustained price-performance improvements for Earth and space science applications		9/04	

Milestones		Previous Baseline	Current Baseline	Actual
FY 05				
6.3	Establish impact on aerospace design and operations through the demonstration of integrated systems of applications, tools, services and resources which enable the high-performance execution of interoperable aerospace applications across distributed heterogeneous testbeds		9/05	
6.4	Establish impact on NASA's education mission through the demonstration of prototype revolutionary multisensory multimedia systems for education		9/05	
7.2	Established sustained utilization of commercial computing technologies for spaceborne applications		9/05	
7.3	Enable sustained use of LT technologies by educational community		9/05	
FY 06				
7.4	Establish sustained use of CAS tools and techniques towards meeting Aero-Space Technology Enterprise goals and objectives (CAS)		9/06	
7.5	Transfer NREN technologies to NASA's operational WAN		9/06	

BASELINE BUDGET

This baseline budget represents current target cost to complete for the program.

FY 01 President's Budget, $M

Project	Code	Prior	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	BTC	Total
Computational Aerospace Sciences	R	225.6	19.8	21.1	22.4	24.2	24.3	22.3	11.5	371.2
Earth and Space Science	Y	131.8	19.7	20.9	20.9	20.9	10.3	0.0	0.0	224.5
Remote Exploration and Experimentation	S	17.8	18.2	24.9	24.9	13.9	13.9	0.0	0.0	113.6
Learning Technologies*		54.8	3.8	4.0	4.0	4.0	4.0	4.0	0.0	78.6
	F	*21.0*	*3.8*	*4.0*	*4.0*	*4.0*	*4.0*	*4.0*	*0.0*	*44.8*
	R	*23.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*23.4*
	Y	*10.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*10.4*
NASA Research and Education Network†		17.9	7.9	4.0	4.0	4.0	4.0	3.1	3.1	48.0
	R	*13.2*	*4.4*	*3.1*	*3.1*	*3.1*	*3.1*	*3.1*	*3.1*	*36.2*
	S	*1.0*	*1.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*2.3*
	Y	*3.7*	*2.2*	*0.9*	*0.9*	*0.9*	*0.9*	*0.0*	*0.0*	*9.5*
Program NOA		447.9	69.4	74.9	76.2	67.0	56.5	29.4	14.6	835.9

* Learning Technologies prior includes Information Infrastructure Technology and Applications (IITA)

† NASA Research and Education Network resources include: FY 98: $10M, FY 99: $7.0M, FY 00: $8.0M

PROGRAM COMMITMENT AGREEMENT

High Performance Computing & Communications (HPCC) Program

Appendix C — Reference Documents

1. High Performance Computing and Communications: FY 1998 Implementation Plan, September 3,1998. Commitments between senior executives of participating federal agencies who sit on the NSTC Committee on Information and Communications (CIC). The Implementation Plan is used to annually review program goals, objectives, technical approaches, management approaches and milestones.
2. Information Technology Research: Investing in Our Future: February 24, 1999 Report to the President of the President's Information Technology Advisory Committee (PITAC) on future directions for Federal support of research and development for information technology.
3. Next Generation Internet Initiative: February 1998 Implementation Plan. Summarizes the goals, resources, management, and time line of the NGI Initiative.
4. PITAC Review of the Next Generation Internet program and Related Issues: April 28, 1999 Report to the President of the President's Information Technology Committee (PITAC) on the implementation of the NGI Initiative.